Remarks

The Office Action dated February 15, 2008 has been received and carefully reviewed. The preceding amendments and the following remarks form a full and complete response thereto. Claim 1 is amended. Claims 2-11 are cancelled without prejudice or disclaimer. Claims 12 – 21 are added. Support for the amendments can be found in the original claims. No new matter is added. Claims 1 and 12-21 are pending in the application and submitted for consideration.

Drawing objections were made. Replacements Figs. 1-2 are submitted herewith. Applicants request that the objections be withdrawn.

Claim 1 was amended to incorporate the limitations of now-cancelled claim 2. Claim 14 corresponds to a combination of original claims 1-3 and 5. Claim 18 corresponds to a combination of original claims 1-3 and 8. Applicants submit that claims 1 and 12-21 are in condition for allowance.

The following prior art rejections were brought:

- Claims 1, 5-6 and 9-11 were rejected under 35 U.S.C. § 102(b) as being anticipated by Holonyak, JR et al. (U.S. Published Application No. 2003/0170927 ("Holonyak").
- Claims 1-11 were rejected under 35 U.S.C. § 102(b) as being anticipated by Yoshida (U. S. Published Application No. 2002/0136932), or alternatively under 35 U.S.C. § 103(a), as being obvious over Yoshida.
- Claims 2-3 and 7-8 were rejected as being obvious over a combination of either Holonyak and F. Hatami et al. ("Radiative recombination from InP quantum dots

in (100) GaP," Applied Physics Letters, vol. 78, no. 15. (4/9/01), pp. 2163-2165)("Hatami") or Yoshida in combination with Hatami.

Each of the rejections is moot in view of the amendments made herein. Applicants submit that claims 1 and 12-21 recite subject matter that is neither disclosed nor suggested by any combination of the cited prior art.

Holonyak describes semiconductor devices in which an active layer is sandwiched between upper and lower InAlP-cladding layer. In the active layer, InAlP quantum dot layers are embedded in a $In_{0,5}(Al_xGa_{1-x})_{0,5}P$ layer structure (compare section 39). The value of x lies between 0.2 and 0.4 (see Figs. 5-7). In addition, devices are described in which InP quantum dot layers are embedded into InAlP layers (compare section 54).

Yoshida discloses a light emitting device that is based on GaN. Between a p-doped layer and an n-doped layer, an active layer is formed, i.e., a light emitting layer. The active layer of Yoshida includes a number of layers into which quantum dots are embedded (compare sections 68 to 80). The quantum dots consist of p-doped GaN and are embedded into a non-doped GaN-layer (compare sections 71 to73).

Hatami describes InP quantum dots which are embedded into a GaP matrix. The quantum dots have lateral dimension of about 100 nm^2 (column 1, 3rd paragraph) and a coverage between 0.5 and 5.8 mono layers (column 2, 1st paragraph). Hatami describes photoluminescence measurements with this structure.

Claim 1, upon which claims 12-13 depend, defines a semiconductor device for emitting light when a voltage is applied that includes a first semiconductor region (3)

whose conductivity is based on charge carriers of a first conductivity type, a second semiconductor region (5) whose conductivity is based on the charge carriers of a second semiconductor type, which have a charge opposite to the charge carriers of the first conductivity type, and an active semiconductor region (7A-7C) which is arranged between the first semiconductor region (3) and the second semiconductor region (5) and in which quantum structures (13) of a semiconductor material with a direct band gap are embedded. The first semiconductor region (3), the second semiconductor region (5) and the active semiconductor region (7A-7C) each include $Al_xGA_{1-x}P$ with $0 < x < 1$ and the quantum structures (13) are made from III-V semiconductor material having a lattice constant which is greater than the GaP.

Thus, in claim 1, not only does the active semiconductor region comprise $Al_xGa_{1-x}P$, but also the first and second semiconductor regions, between which the active region is located, comprise $Al_xGa_{1-x}P$.

In contrast, Holonyak discloses that its active region comprises InP quantum dot layers which are embedded in $In_{0,5}(Al_xGa_{1-x})_{0,5}P$, $0,3 \leq x \geq 0,4$. In other words, the layers into which the InP quantum dots are embedded always comprise a substantial amount of In and P - - the material of which the quantum dots are made. Furthermore, in Holonyak, the layers between which the active layers are arranged comprises In and P. Thus, all layers comprises In and P, i.e., the quantum dot material and Holonyak cannot anticipate the features of claim 1.

Hatami describes an active layer of InP quantum dots which are embedded in GaP. Hence, Hatami teaches to use no In in the matrix. Furthermore, Hatami does not

describe to locate the GaP matrix with the InP quantum dots between further GaP layers. Thus, Applicants submit that a person skilled in the art would not be have found it obvious to derive the structure as claimed in claim 1, i.e. a structure of which a III-V semiconductor quantum dots containing $Al_xGa_{1-x}P$ matrix is located between $Al_xGa_{1-x}P$ layers, by a combination of Holonyak and Hatami.

Yoshida discloses that the quantum dots are made from p-doped GaN and are embedded in un-doped GaN layers. Thus, Yoshida fails to disclose or suggest to locate an active layer comprising quantum structures made from a III-V semiconductor material that are embedded in $Al_xGa_{1-x}P$ layers, between $Al_xGa_{1-x}P$ layers, as claimed in claim 1 of the present application.

Thus, claim 1 is not anticipated by Holonyak, and is neither rendered obvious by Holonyak in view of Hatami nor Yoshida in view of Hatami. Thus, each of the rejections to claim 1 is improper and must be withdrawn, and claims 1 and 12-13 are allowable.

Claim 14 defines a semiconductor device for emitting light when a voltage is applied that includes a first semiconductor region (3) whose conductivity is based on charge carriers of a first conductivity type, a second semiconductor region (5) whose conductivity is based on the charge carriers of a second semiconductor type, which have a charge opposite to the charge carriers of the first conductivity type, and an active semiconductor region (7A-7C) which is arranged between the first semiconductor region (3) and the second semiconductor region (5) and in which quantum structures (13) of a semiconductor material with a direct band gap are embedded. <u>The first semiconductor</u>

region (3), the second semiconductor region (5), and the active semiconductor region (7A-7C) each include $Al_xGA_{1-x}P$ with 0 < x < 1. The quantum structures (13) are made from a III-V semiconductor material including InP. The quantum structures (13) are of a lateral extent which on average is less than about 50 nm.

The Office Action implies that the feature that the quantum structures are made from a semiconductor material including InP and the feature that the quantum structures are of a lateral extend which on average is less than 50 nm can be found in Yoshida. However, Yoshida fails to give any indication about the lateral dimension of this quantum dots.

Holonyak discloses a range of 10 to 200 Å (1 to 20 nm, see section 15 of Holonyak) for the lateral size of InP quantum dots. However, this description is for InP quantum dots which are embedded in $In_{0,5}(Al_xGa_{1-x})_{0,5}P$, i.e., the dots of Holonyak are embedded in a matrix that is a different material than the matrix of the semiconductor device claimed in claim 14. Since the properties of the band gap also depend on the material into which the quantum dots are embedded, the lateral extension given by Holonyak cannot simply be transferred to the materials used in the semiconductor device claimed in claim 14. Thus, Holonyak cannot be applied to claim 14 without the use of improper hindsight.

Hatami, on the other hand, which uses InP quantum dots embedded in a GaP matrix, describes lateral dimensions of the quantum dots which are a factor two larger than what is claimed in claim 14.

Thus, Applicants submit that the subject matter of claim 14, upon which claims 15-18 depend, is not disclosed or suggested by the combination of cited prior art, and is thus, patentable over the combination of cited prior art.

Claim 18 defines a semiconductor device for emitting light when a voltage is applied that includes a first semiconductor region (3) whose conductivity is based on charge carriers of a first conductivity type, a second semiconductor region (5) whose conductivity is based on the charge carriers of a second semiconductor type, which have a charge opposite to the charge carriers of the first conductivity type, and an active semiconductor region including a plurality of sub-regions (7A-7C) arranged between the first semiconductor region (3) and the second semiconductor region (5) and in which quantum structures (13) of a semiconductor material with a direct band gap are embedded. The first semiconductor region (3), the second semiconductor region (5) and the active semiconductor region (7A-7C) each include $Al_xGA_{1-x}P$ with $0 < x < 1$. The quantum structures (13) are made from a III-V semiconductor material including InP and are of a lateral extent which on average is less than about 50 nm. The sub-regions have different InP coverages.

The specific InP coverage and the shape of the quantum dot layer having sub-regions of different sizes (e.g., layer 15 shown in Fig. 2 of the present application) is not disclosed or suggested by the combination of cited prior art; nor are the specific layer dimensions. Thus, claim 18, upon which claims 19-21, is patentable over the cited prior art.

The claims were provisionally rejected over the claims of a related application for double patenting. Since claims in the related application have not been allowed at this point, it is premature to take a position with respect to the provisional double patenting rejection. Accordingly, Applicants request that this rejection be held in abeyance until one of the applications is allowed.

In view of the above, all objections and rejections have been sufficiently addressed. The Applicants submit that the application is now in condition for allowance and request that claims 1 and 12-21 be allowed and this application passed to issue.

In the event that this paper is not timely filed, the Applicants respectfully petition for an appropriate extension of time. Any fees for such an extension together with any additional fees may be charged to Counsel's Deposit Account No. 02-2135.

If for any reason the Examiner determines that the application is not now in condition for allowance, it is respectfully requested that the Examiner contact, by telephone, the Applicants' undersigned attorney at the indicated telephone number to arrange for an interview to expedite the disposition of this application.

Respectfully submitted,

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Date

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